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# A Computer Model for Trailer Optimization in a Cotton Harvesting System

George R. Baskin

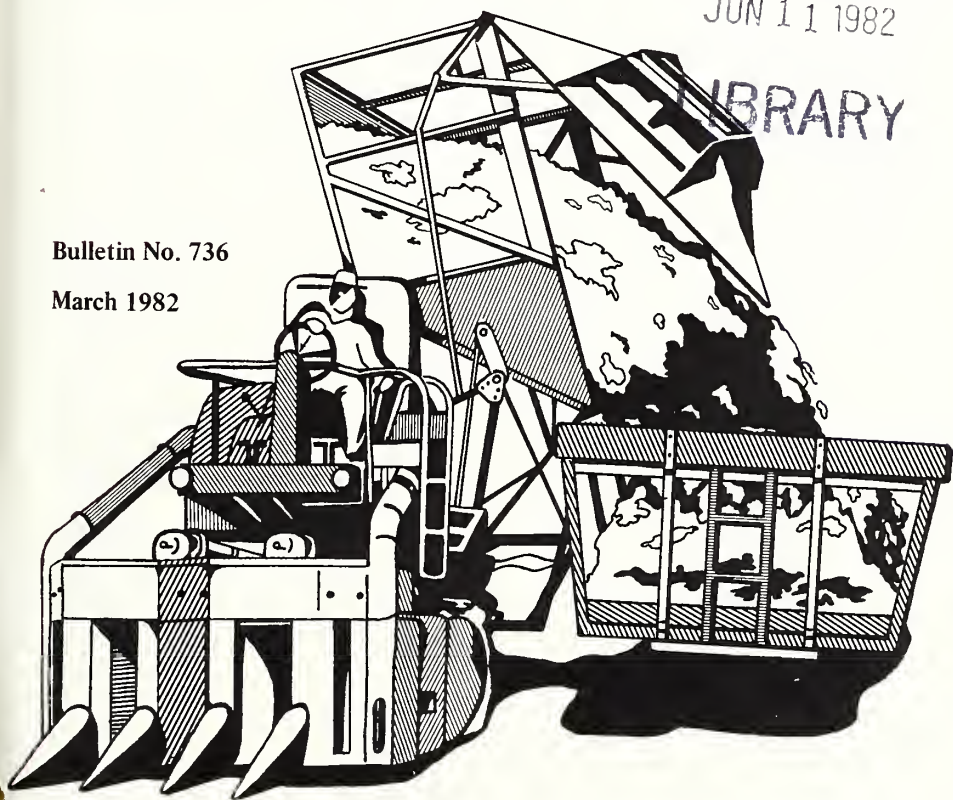
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# A Computer Model for Trailer Optimization in a Cotton Harvesting System

GEORGE R. BASKIN AND FRED E. SISTLER<sup>1</sup>

Inflation has hit the cotton farmer. The prices of products he must buy to produce a crop have risen drastically, but the price he receives for his cotton has not kept pace with his production costs (3).<sup>2</sup>

The cotton farmer must produce his crop more efficiently to remain in business. The computer can be a valuable tool in farm management; computer models can pinpoint where the farmer's dollars should be invested to reap the greatest returns.

Harvesting is one of the most important steps in cotton production because the crop must be harvested before weather can lower its quality. The cotton farmer must consider not only the fixed and operating costs of a harvesting system but also the ability of the system to harvest the crop within the allowable harvest season.

A computer program based on information from farm records has been developed to aid in the design of the cotton harvesting system. The performance rates and fixed and operating costs of five components are included—the cotton harvester, the trailer transport vehicle, cotton trailers, the gin, and labor.

The computer model divides cotton harvesting into two segments. The picking subroutine assumes a cotton harvester and the cotton trailers in the field. When the basket is full, the harvester dumps the cotton into a trailer if one is available; if not, it waits for an empty trailer to return to the field. Each trailer is filled to capacity.

The transport subroutine simulates all the cotton trailers in the field or at the gin and a truck to pull the trailers. The truck takes the full trailers to the gin, returns the empty trailers to the field, and remains in the field when no trailers are waiting for transport. The truck brings all trailers emptied at the gin, returns the empty trailers to the field, and remains in the field when no

The model has a weather component based on data collected concerning the number of days suitable for fieldwork (1). Depending on the date on which the farmer decides to begin his harvest, the model accounts for a given number of days on which the system will be idled by weather.

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<sup>2</sup>Italic numbers in parentheses refer to Literature Cited, page 15.

**Date in this publication are reported in English units of measure. For conversion to metric equivalents, 1 acre = .4047 hectare, and 1 mile = 1.6093 kilometers.**

Many of the concepts used in developing this model have been adapted from a report on a sugarcane transport system designed by Cochran and Whitney (2). The actual components in the cotton harvesting system have been based on the authors' experience. The data used to evaluate the program were from reports on cotton production costs and agricultural statistics for Louisiana (3, 4, 5).

## Assumptions and Limitations of the Model

The model was developed for a one-harvester, one-truck system. The number of trailers was varied from one to 15. For a system with more than one picker, average values for picking rate, fixed costs, etc., could be used in the model to give a reasonable estimate for a multiple-picker system. At present there is no convenient way to increase the number of trucks used to transport trailers to and from the gin in the model.

The gin time for trailer turnaround was assumed to be constant throughout the harvesting season, but this is not completely accurate because turnaround time varies widely. Gin turnaround times of 48 and 96 hours were used in the model.

An approximate count was used for days not worked due to unavailability of trailers. If more than 75 percent of the working day was worked, it was considered a whole working day; if 50 to 75 percent of the day was worked, it was half a working day. If less than 50 percent of the working day was used, it was not included as a working day.

The length of a full working day was assumed to be constant. The work day began with the picker, truck, and available empty trailers already in the field. Servicing and maintenance of equipment and travel time to and from the field were not included in the work day. Operating costs, which included all maintenance and service costs, and labor costs were considered separately.

The harvest season was limited to the period from September 20 through December 31 (103 days). Estimated harvesting delays caused by bad weather were based on the study by Bolton *et al.* (1). The computer model assumed the weather caused either a full day's delay or no delay at all. Each day's weather was considered to be unaffected by the weather of the preceding day. The economic loss related to deterioration in quality and quantity of mature cotton subjected to bad weather was not considered because that information was unavailable. If this economic loss had been included, it would have shown extra trailers to be of greater economic value to the farmer when harvesting was delayed by a lack of empty trailers.

The availability of rental trailers from the gin was not considered. However, the program did consider an average fixed and operating cost for

the trailers. Therefore, for a situation with both rented and farmer-owned trailers, the average costs could be applied in the model if the number of trailers remained constant throughout the harvesting season. There was no way for the program to consider a system in which the number of trailers varied during the harvest season.

## Results

The computer program was run with various yield levels, farm sizes, numbers of pickers, ginning times, and soil types. The farm sizes used were 200, 400, 600, and 800 acres. For the 400 acre farm, the yield was varied from .75 to 1.5 bales per acre. The one- and two-picker systems were tested on the 600- and 800-acre farms. The effect of inefficient picker operation was also tested and examined. When one factor was varied, all other variables were held constant (Table 1).

The effect of trailer capacity was modeled using four-, seven-, and ten-bale trailers (Figure 1). It usually required fewer large trailers than small trailers to achieve the minimum harvest cost. The use of larger trailers showed a slight trend toward a lower overall harvesting cost. In every case, the least harvest cost and minimum harvest season length occurred with the same number of trailers. The harvest season length stabilized after the minimum point (Figure 2). The picker was 100 percent utilized at this point and never stopped to wait for a trailer to return from the gin. The addition of trailers beyond this optimal point did not drastically increase cost. The grower could invest in one or two additional trailers at very little extra cost as insurance against a rainy year or gin breakdown.

When picker rates of 1 and 1.75 acres per hour were compared (Figures 3 and 4), the higher rate required more trailers and had a lower per-bale harvesting cost. The slower picker rate raised harvest costs by \$20 per bale, used the maximum harvest season of 103 days, and left 50 bales of cotton in the field on a 400-acre farm.

Table 1.—Sample inputs for the cotton harvesting model

Picker data		Trailer data	
Operator's wages = \$3.50/hour		Fixed cost = \$190.33/year	
Fixed cost = \$3,940/year		Operating cost = \$.03/mile	
Operating cost = \$24.85/machine hour		Capacity = 10 bales	
Picking rate = 1.75 acres/hour		Average gin turnaround time = 48 hours	
Basket capacity = 2 bales			
Truck data		General input data	
Driver's wages = \$3.50/hour		Average distance to gin = 8.5 miles	
Fixed cost = \$.06/mile		Average working day length = 10 hours	
Operating cost = \$.11/mile		Total cotton acreage = 400 acres	
		Average yield = 1 bale/acre	



The effect of ginning time was evaluated for 48- and 96-hour turnaround times (Figures 5 and 6). The longer ginning time increased the number of seven-bale trailers needed to minimize harvesting cost from seven to 10.

Farm size had little influence on the optimal number of trailers. Farms

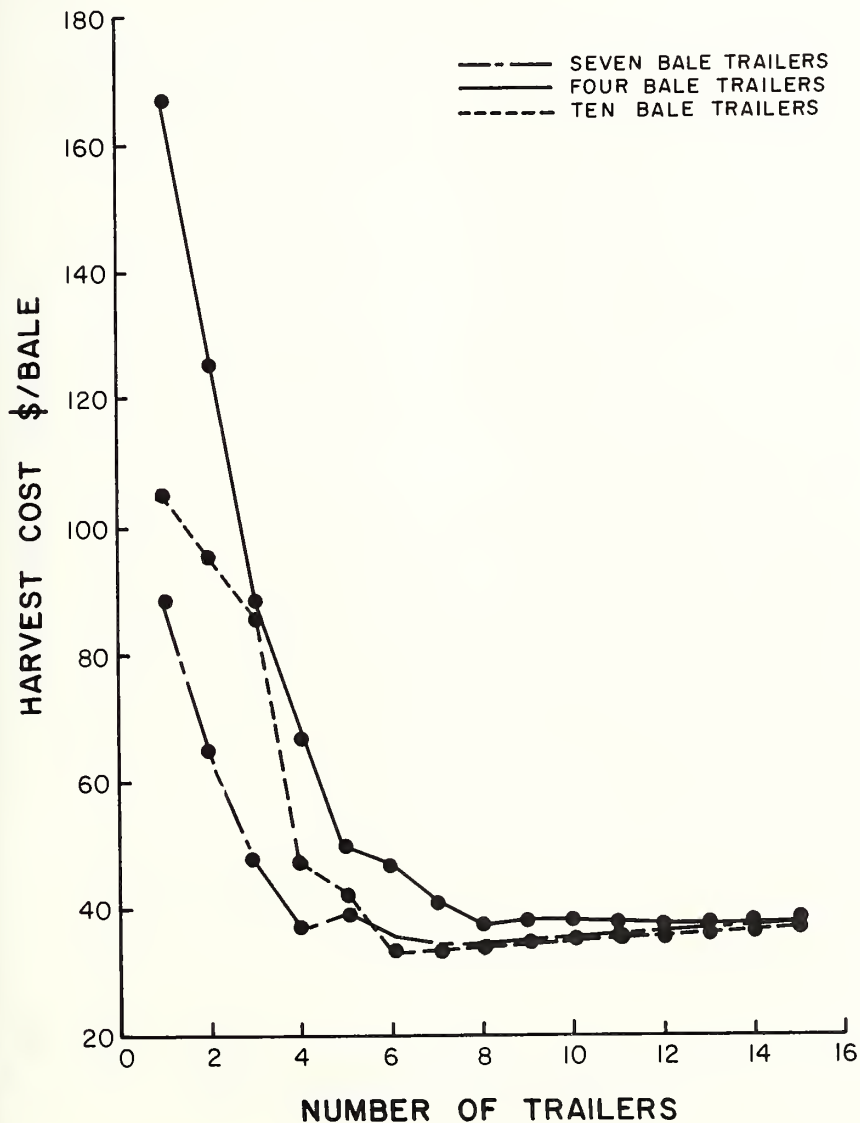


Figure 1.—Effect of trailer size on harvest cost. (400-acre farm, 1 picker with 1.75 acre/hr rate, 48-hr gin time.)

from 200 to 600 acres all required six 10-bale trailers if one picker was used. Farms of 600 acres and larger with two pickers needed eight 10-bale trailers.

Farm size had little effect on the system performance (Figures 7 and 8). However, the results for the 600-acre farm with one- and two-picker

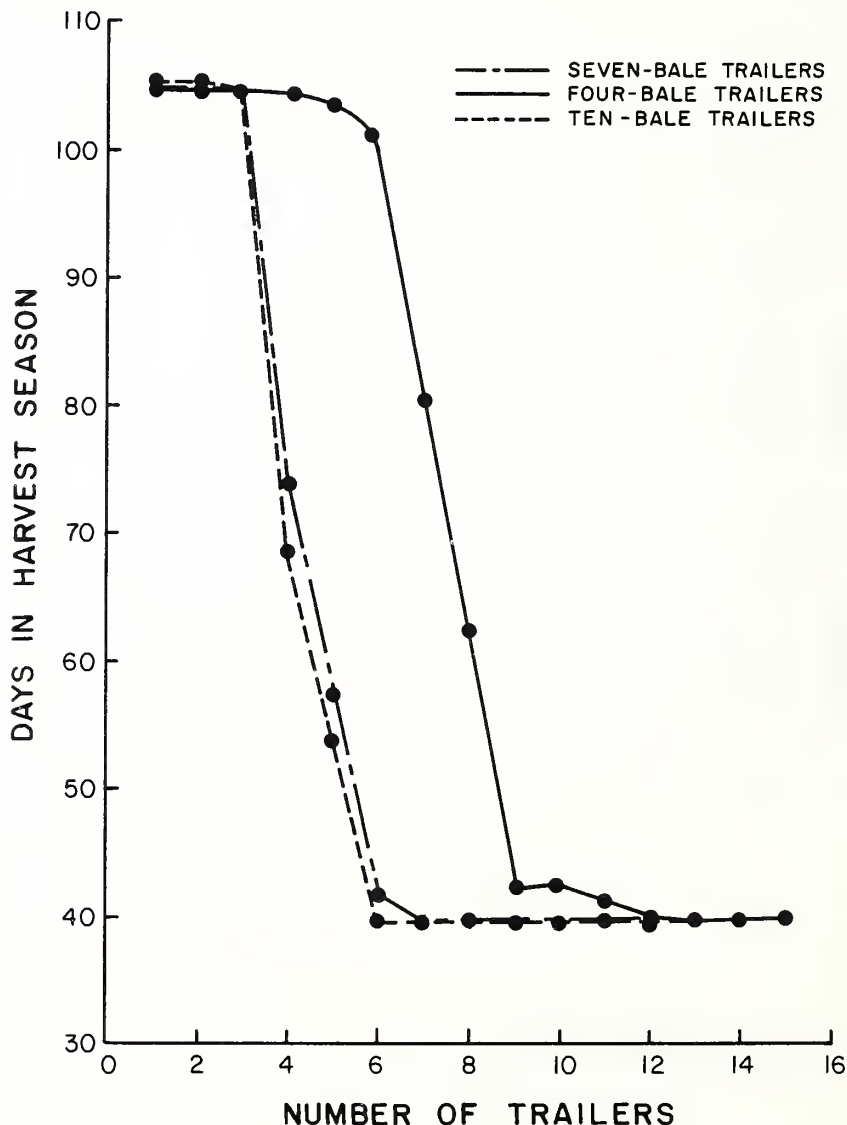


Figure 2.—Effect of trailer size on harvest season length. (400-acre farm, 1 picker with 1.75 acre/hr rate, 48-hr gin time.)

systems showed that both the lease cost and minimum harvest season must be considered. While the one-picker system is less expensive, the associated 85-day harvest season is unacceptable. For best performance, the two-picker systems generally required more trailers than did the one-picker systems.

Sensitivity to crop yield was examined on the 400-acre farm with yields

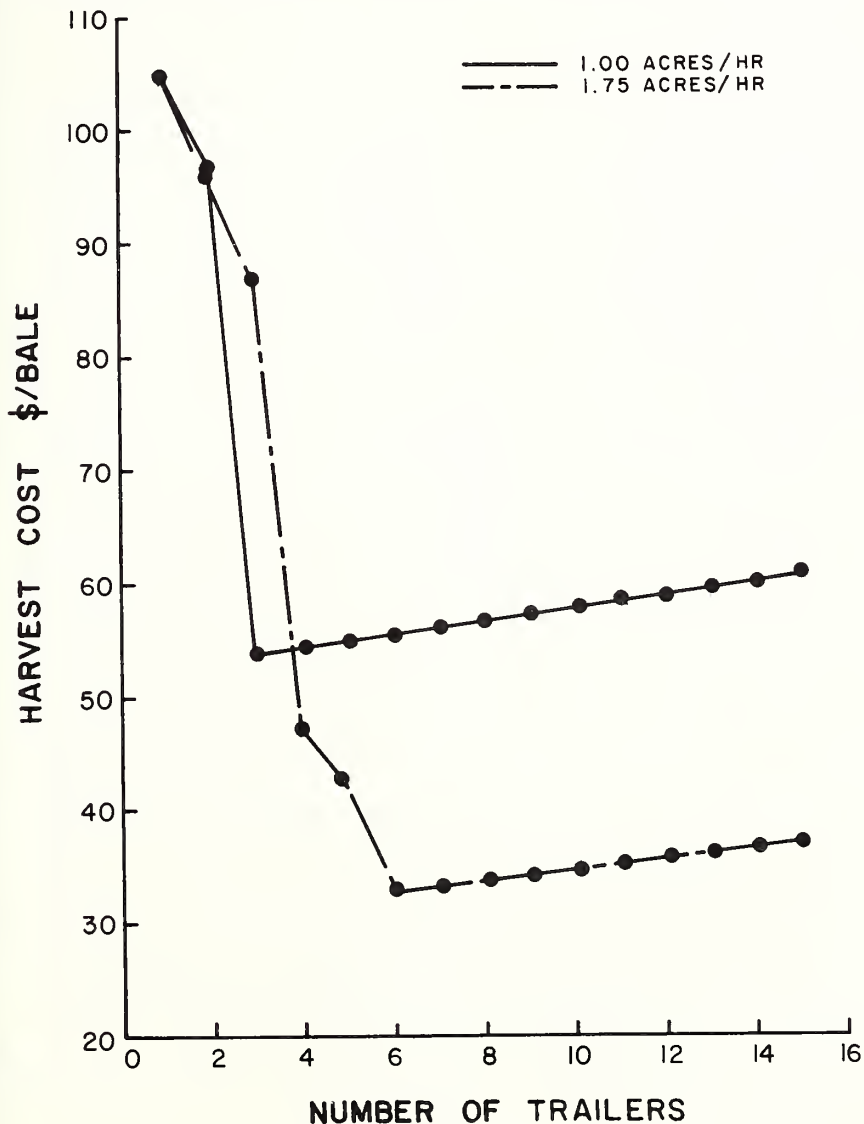


Figure 3.—Effect of picking rate on harvest cost. (400-acre farm, 10-bale trailers, 1 picker, 48-hr gin time.)



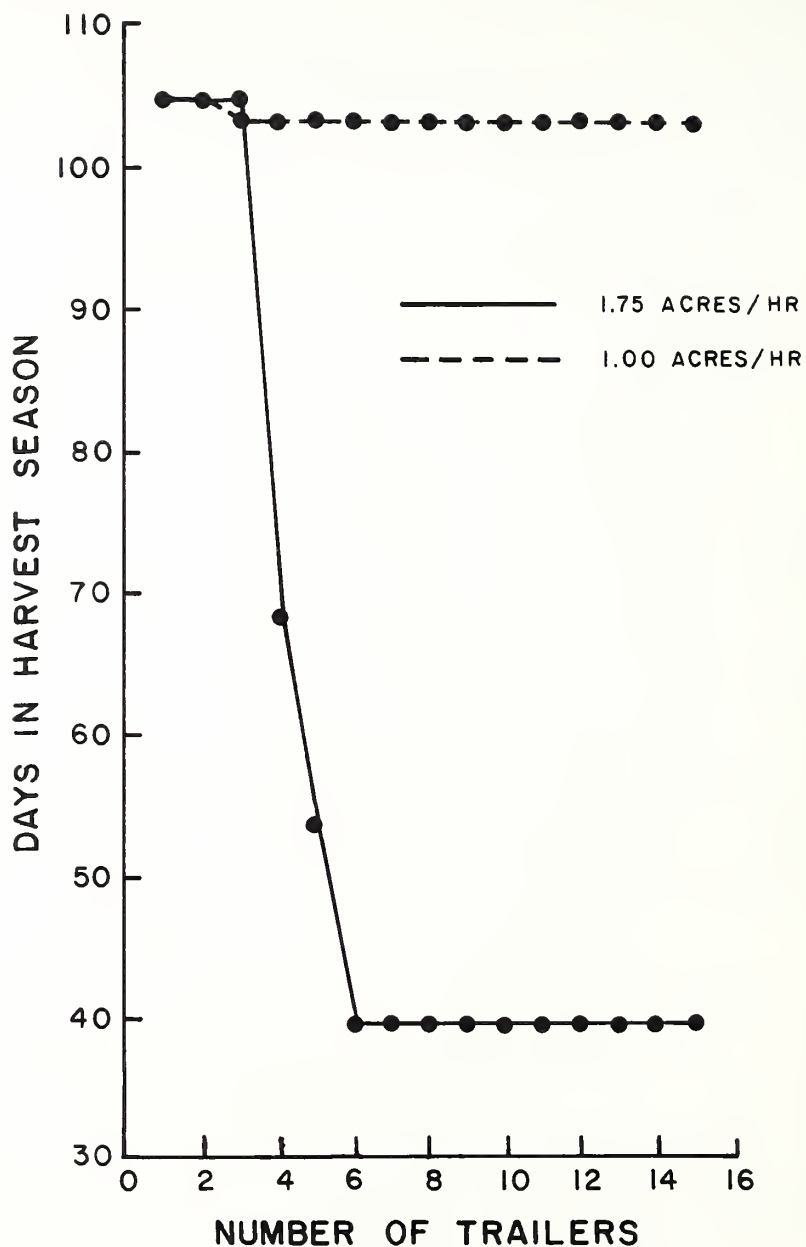


Figure 4.—Effect of picking rate on harvest season length. (400-acre farm, 10-bale trailers, 1 picker, 48-hr gin time.)

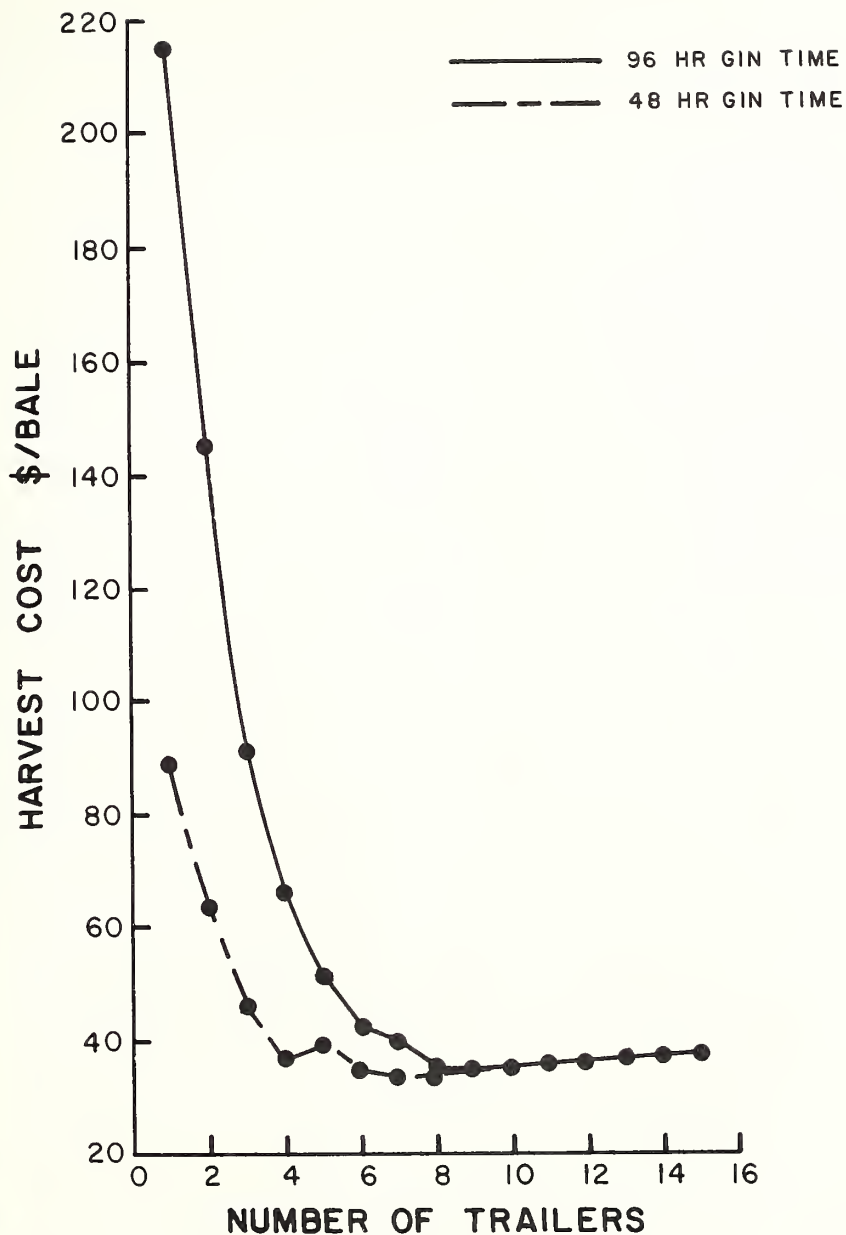


Figure 5.—Effect of gin time on harvest cost. (400-acre farm, 7-bale trailers, 1 picker with 1.75 acre/hr rate.)

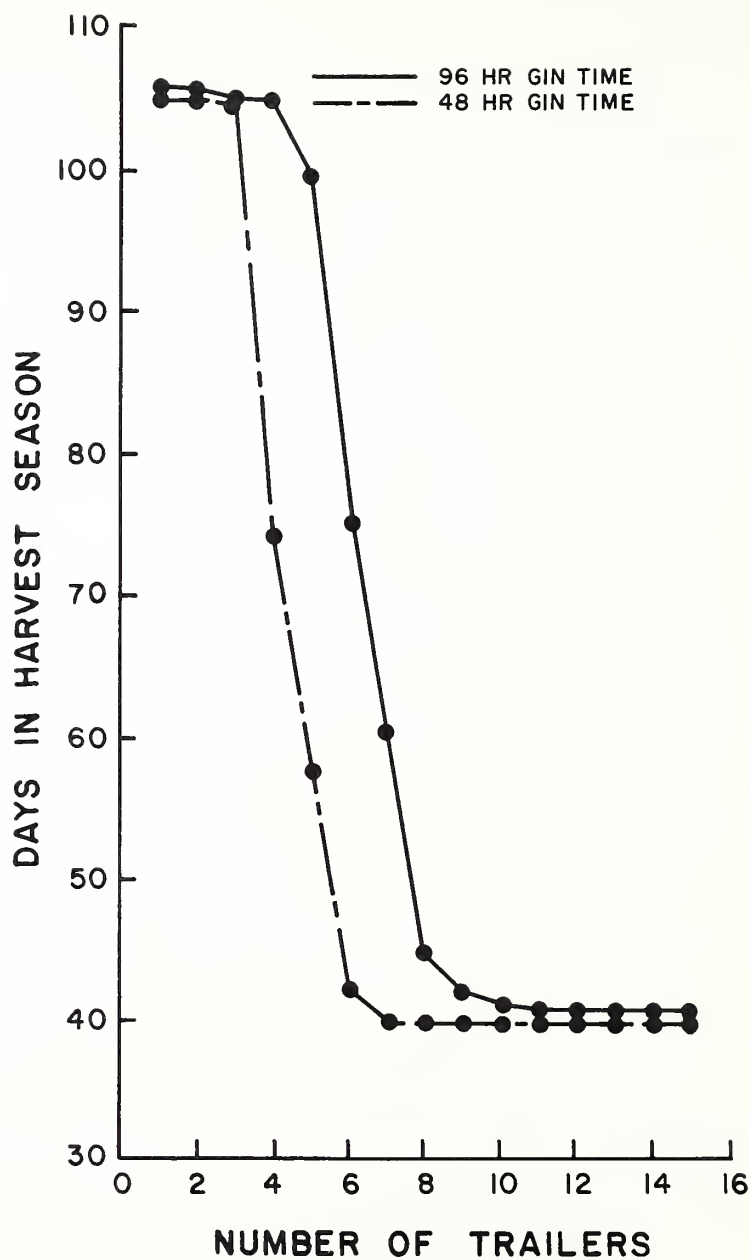


Figure 6.—Effect of gin time on harvest season length. (400-acre farm, 7-bale trailers, 1 picker with 1.75 acre/hr rate.)

of .75, 1, and 1.5 bales per acre (Figures 9 and 10). As yield increased, more trailers were needed for best performance. The number of trailers for optimum performance increased from four with a .75 bale per acre yield to eight for a 1.5 bales per acre yield.

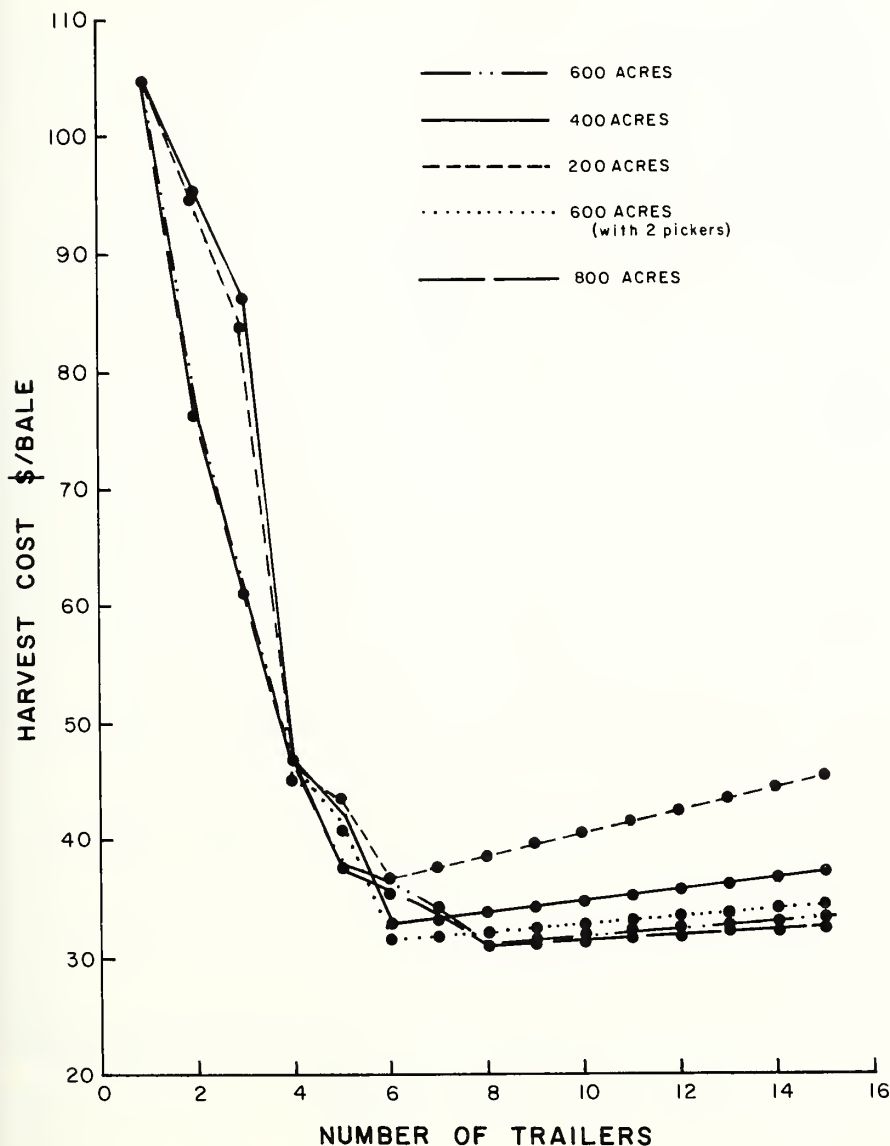


Figure 7.—Effect of farm size on harvest cost. (10-bale trailers, 1 picker with 1.75 acre/hr rate, 2 pickers with 3.50 acre/hr rate, 48-hr gin time.)

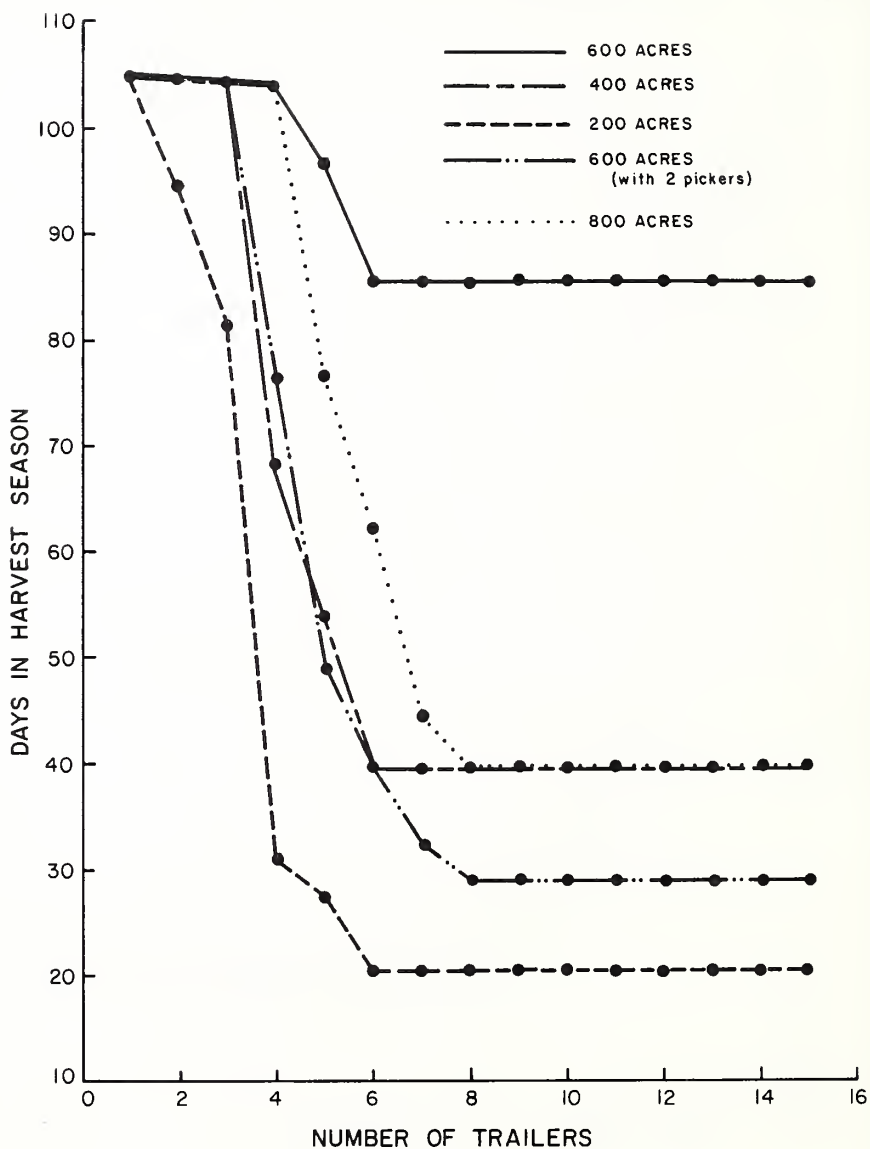


Figure 8.—Effect of farm size on harvest season length. (10-bale trailers, 1 picker with 1.75 acre/hr rate, 2 pickers with 3.50 acre/hr rate, 48-hr gin time.)

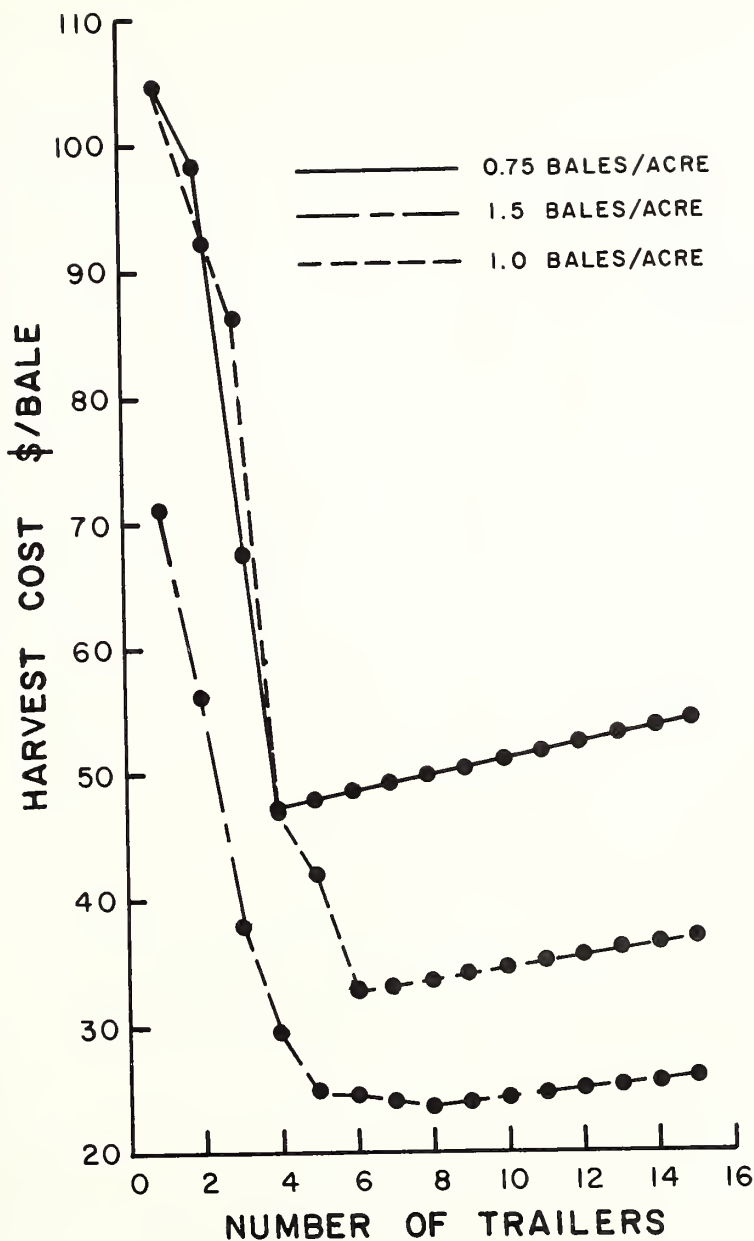


Figure 9.—Effect of yield on harvest cost. (400-acre farm, 10-bale trailers, 1 picker with 1.75 acre/hr rate, 48-hr gin time.)



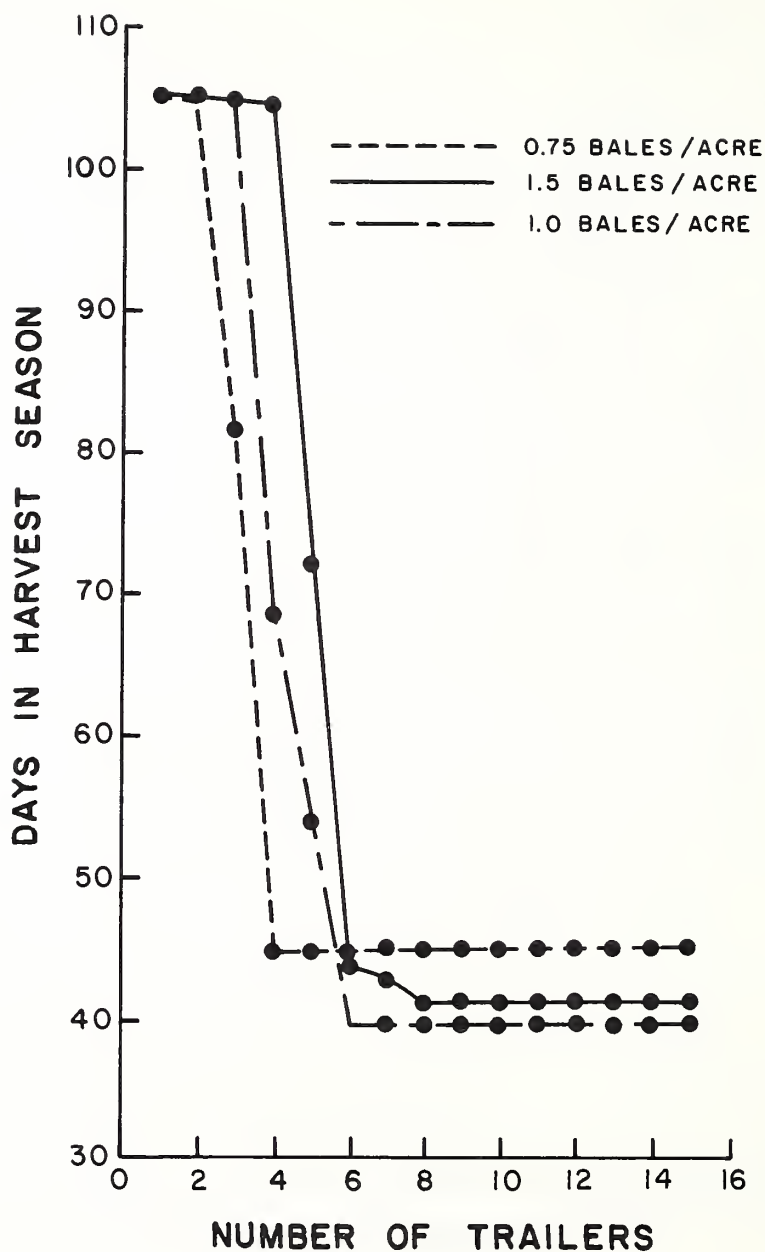


Figure 10.—Effect of yield on harvest season length. (400-acre farm, 10-bale trailers, 1 picker with 1.75 acre/hr rate, 48-hr gin time.)

## Summary

Increasing the number of trailers increased the delivery rate of cotton to the gin until the system was limited by the picking rate. The least-cost point was always where the picking rate limited the delivery rate to the gin. Extra trailers added past the least-cost number increased the harvest cost very slightly. This indicates the additional cost of an extra trailer or two as insurance against bad weather or gin breakdowns would be a sound investment.

According to Paxton (5), the projected 1979 harvest costs for Louisiana ranged from \$28.98 to \$45.98 per acre. Using projected costs and statistics for 1978, the model predicted harvesting costs of approximately \$34.00 per acre.

## Conclusions

1. The picker must be kept busy for a low-cost harvesting operation.
2. A one-picker system requires at least six 10-bale trailers.
3. A two-picker system requires at least eight 10-bale trailers.
4. One or two trailers more than the least-cost number of trailers will not drastically increase harvest costs and may be a sound investment as insurance against unusually bad weather and gin breakdowns.

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